

Accuracy and Performance Requirements for Frostpoint Hygrometers in Trend Detection and Network Operations

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The Boulder record of balloonborne stratospheric water vapor observations is the longest of its kind. The past 10 years show no increase in the lower stratosphere and an increase of more than 1.5% above 26 km. This simple trend calculation assumes an instrument with perfect precision and does not consider production variability and the resulting precision limitations. If these factors are included in the trend analysis, the measured trend is not statistically different from constant water vapor in the stratosphere over this time period. The water vapor mixing ratio in the 20-22 km layer is shown as an example in figure 1. The last major instrument change happened in 1990. This allows for the interpretation of zero increase throughout the 1980s and zero increase after 1991. While the precision of the instrument was most likely not affected by this change, it cannot be excluded that the accuracy of the measurement changed, which may have contributed to this step change.

To identify a trend of $1\% \text{ yr}^{-1}$ over a 10-year period, the instrument precision has to be better than 10% and changes between individual instruments must not affect the measurement accuracy.

Network operations cannot only focus on trend detection, but also need to focus on process studies, for example Polar Stratospheric Cloud (PSC) formation, transport and mixing, tropopause cirrus cloud, and dehydration processes. Therefore, both optimal precision and accuracy are required. Network operations also demand an instrument that is easy to operate, lightweight, and economical while at the same time providing data over the entire altitude range and under varied meteorological conditions. The University of Colorado balloonborne Cryogenic Frostpoint Hygrometer (CU-CFH) implements various improvements in accuracy and precision as well as performance and is the most lightweight instrument of its kind.

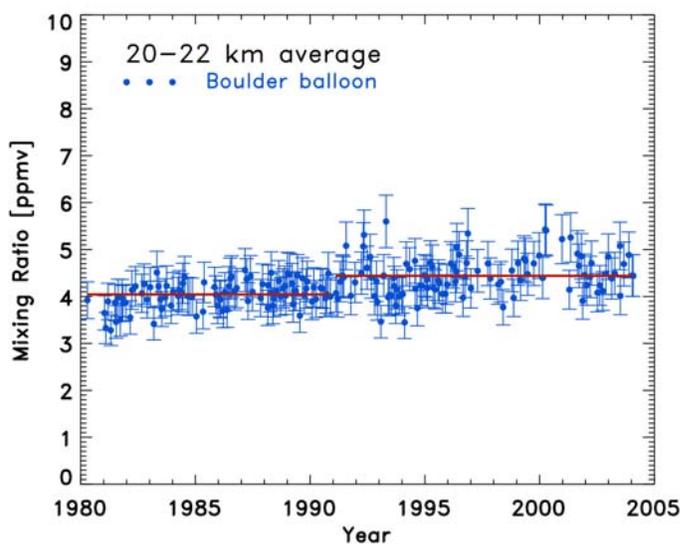


Figure 1. Water vapor over Boulder measured by the CMDL balloonborne frostpoint hygrometer in the 20-22-km layer. The vertical bars indicate the 10% accuracy range of this instrument. The horizontal lines indicate the mean value for 1980-1990 and 1991-2004. The transition was chosen at the time of the transition from analog to digital data transmission.